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The report further emphasized a need for better training, education, communication, and the development of codes of practice in which all those who are potentially responsible for spills of chemicals into the Great Lakes should acknowledge the importance of preventative aspects.

It is likely that within programs such as MISA, strenuous efforts will be devoted to ensuring that the Best Available Technology includes efforts to conduct operations in such a way that spills are avoided, and even if they do occur, they will not reach vulnerable waterways. The recent million gallon (3 785 412 dm^3) diesel oil spill into the Monongahela and Ohio Rivers in the U.S. is a clear example of an incident which need not have occurred, had the tank been properly bermed. The design of such facilities should build in the requirement that failure of the vessel will not result in spillage to the environment. A second "fail-safe" line of defence is needed.

Conclusions

There has been a tendency in recent years for most environmental protection efforts to be devoted to monitoring, treating and regulating chronic emissions. Whereas this devotion to chronic emission reduction is desirable, it is also important to ensure that there is consistency between efforts to regulate chronic emissions and those applied to episodic emissions or spills. It appears that most present regulatory enthusiasm is being applied to control chronic emissions, but relatively little effort is being devoted to measuring and reducing spill frequency, or to cleaning up or mitigating the spills. We do not know the relative contributions of each source, but it is certain that as chronic emissions are reduced, spills will become, in relative terms, a much more significant source of contaminants to the environment.

Regrettably, the resources devoted to spill prevention and clean-up seem to be controlled more by the intensity of public outcry and indignation after periodic spill incidents. Fortunately for society (but unfortunately for spill researchers) there have been very few recent disastrous spill incidents. We would be foolish to assume that there will never be another Mississauga chlorine incident, or "Arrow" tanker grounding. What we need is a consistent, balanced, long-term program of research into all aspects of chemical emissions, including continuing scrutiny of relative magnitudes of all sources, including water quality modelling, to link the emission rates to concentrations in water, fish, and wildlife.

Finally, "spillers" should take heart; if the "chroniclers" do a fine job they will put themselves out of business and the importance of spills and "spillers" will again become appreciated.

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EVALUATION OF A WATER JET BARRIER IN ICE CONDITIONS

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Introduction

Limitations of conventional barriers for containment and deflection of oil spills in currents of more than 0.514 m/s (1 knot) stimulated the study of alternative systems which function by generating a horizontal surface current to oppose the movement of floating oil. Air jets were tested at the United States Environmental Protection Agency's (EPA) OHMSETT facility (Cohen, Lindenmuth, 1979) but it was shown that a large pressure drop in the duct would preclude the development of an operational barrier.

Plunging water jets were also tested at the same facility (Nash, Farlow, 1984). Used with low pressure (150 kPa) and high water volume (5.0 L/s), they showed good efficiency in a deflection configuration. Unfortunately, the logistics increase rapidly with the deflection distance and current strength.

Flat-fan high-pressure water jets, placed horizontally above the surface of the water, which showed potential in tank testing at OHMSETT, were used in an array configuration in rivers and canals (Meikle, Whittaker, Laperrière, 1985). Deflection in currents of about 1.028 m/s (two knots) was possible even though the system used was not fully optimized. Alternative uses of this technique, such as containing oil in the presence of floating ice, sweeping and protecting tidal mud floats, and burning floating oil in-situ more efficiently, were identified and considered for further testing.

The evaluation discussed in this report is the containment of oil in the presence of ice. The objectives were to assess the influence of flat-fan high-pressure water jets on ice floes moving towards the deflector, and the extent to which flat-fan high-pressure water jets used in ice floes could deflect oil.

Testing Area

Knowing the limitations of Environment Canada's high-pressure water jet prototype barrier in open water, very specific ice and current conditions were sought; 1.5-10 m^2 ice floes, low density ice cover and less than 0.514 m/s (one knot) current. Simulation in a tank was not possible because of the large testing area required. The desired ice and current conditions can generally be found in some locations on the St. Lawrence River in the spring. Two sections of the river were considered in the vicinity of the Trois-Rivières and Québec harbours.

Testing was to be aided by Canadian Coast Guard ice-breakers. Logistic problems related to the assembly/disassembly of the prototype barrier were to be minimized using a vessel to move the barrier to the best testing area(s), with the power generation system on board and operated from the vessel.

In March 1987, ice on the St. Lawrence River broke-up earlier than usual, and the selected harbours did not have drifting ice floes. Other possible areas were examined on March 24, 1987 (private harbours and sheltered basins) but sudden shifting winds cleared the ice from these areas before testing could start. An attempt to evaluate the barrier was finally made on March 26, 1987 in the St. Charles River estuary, near Qu?bec. Ice coverage was about six to seven eighths.

Testing

The barrier, its possible configurations and the power system, are described elsewhere (Meikle, Whittaker, Laperrière, 1985). A barrier length of 10 m was assembled on the dock and loaded onto the deck of the ice-breaker, "Bernier", with the high-pressure pump. A short length of the barrier (half of the usual) was used because of anticipated control and manoeuverability difficulties in such ice conditions. The use of a small boat for adjustments was not possible because of the amount of ice present. Both ends of the barrier were attached to a rope and the barrier was lifted on board with a crane when adjustments were necessary.

The barrier could not be tested while the vessel's propellors were operating. The turbulence they generated cleared the ice from the water surface for a 12-15 m radius around the vessel. Due to the high density ice coverage, the water surface around the vessel was first cleared and the barrier was deployed alongside the vessel by a crane. The jets were operated at 6895 kPa (1000 psi) and the ice floes were pushed towards the barrier by a motorized barge (Photo 1).

PHOTO 1

At a pressure of 6895 kPa and a flow of 0.93 L/s/jet (15 U.S. gpm/jet), the jets could not push away the floes that were already in contact with the floats. However, when the floes were pushed in front of one of the jets, they were deflected very slowly (Photos 2 and 3).

It was difficult to estimate the distance at which the ice floes in front of the barrier were influenced by the jets because the floes could never be brought towards the barrier in exactly the same manner. However, during the deflection of one ice floe measuring about 3 m^2 by 1 m thick with about 0.15 m of freeboard, a deflection

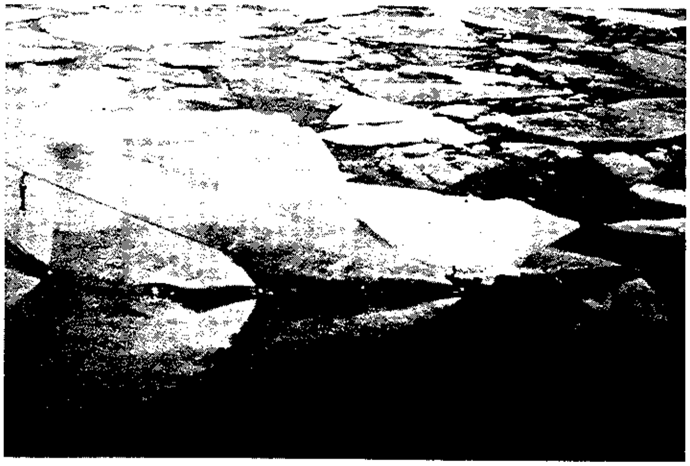

PHOTO 2

PHOTO 4

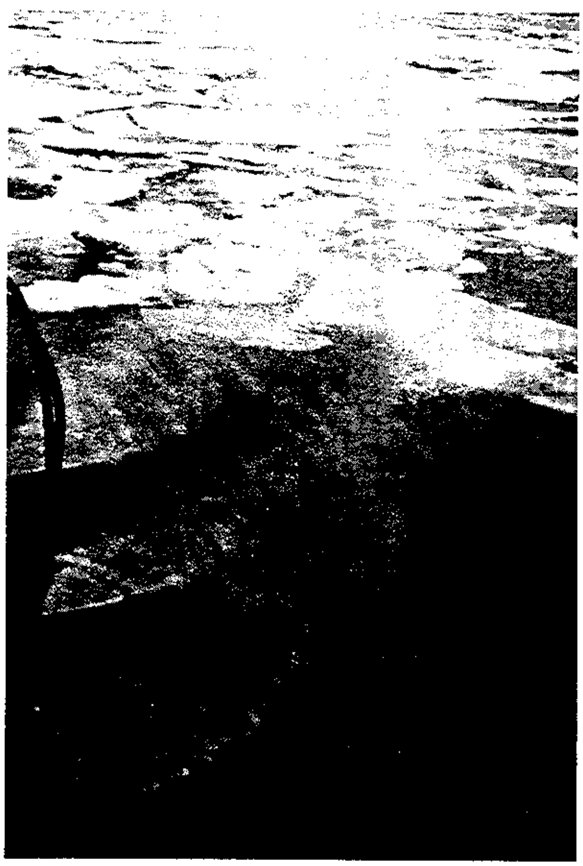

PHOTO 3

distance of 1.8-2.4 m was achieved using a pressure of 6895 kPa (Photo 4).

The influence of the jets on spilled peat moss between and behind isolated ice floes could not be established. Difficulties controlling the number of ice floes in front of the barrier and the clearance between them precluded accurate measurements. The jets were deflecting the mass of ice rather than just the peat moss.

There was some water turbulence up to 6.0 m from the jets in openings of about 0.8 m wide, parallel to the jets. However, in similar openings, 0.3 m wide, there were no ripples on the water surface at 4.5 m from the barrier. No turbulence was noticed behind ice floes at a distance of about 3.0 m from the jets (Photos 5 and 6).

From previous tank testing with water jets of the same type, aperture, angle and height, we know that air flows generated have a noticeable velocity up to 6.0 m away. This does not conflict with the observations made during this evaluation. In wide openings, parallel to the jet, the same water turbulence was observed. In smaller ice openings aligned parallel to the jet, the influence of the

PHOTO 5

edges of the ice seem to be more important since surface turbulence is less noticeable. Ice strongly reduced water turbulence in openings perpendicular to the jet.

Observations on the sheltering effect of the ice were done without peat moss. Observations with peat moss, or preferably with oil, in a controlled environment are required to assess the limitations of high pressure water jets in an ice environment.

Conclusions

This short test showed that although water jets may have some potential in ice, the present barrier arrangement is not suitable because of the lack of clear space between supporting floats.

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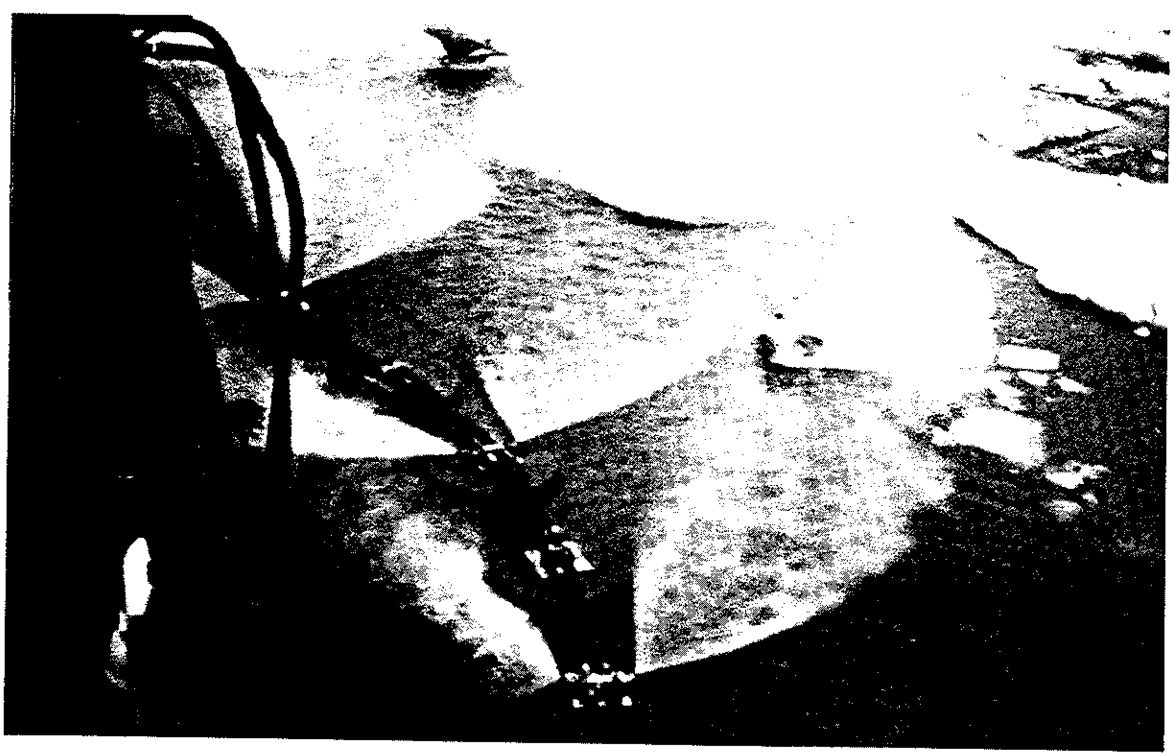

PHOTO 6

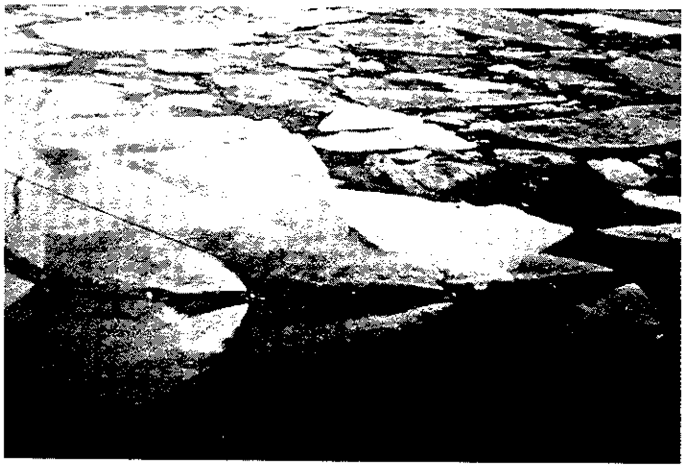

PHOTO 2

PHOTO 4

PHOTO 3

Conclusions

Cet essai relativement bref a montré que, même si les jets d'eau présentent des possibilités intéressantes en présence de glace, la configuration actuelle de la barrière ne convient pas, en raison du manque d'espace entre les flotteurs de soutien.

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PHOTO 5

PHOTO 6